REPORT OF COMMISSIONERS

APPOINTED

UNDER RESOLVE OF 1856, CHAP. 58,

CONCERNING THE

Artificial Propagation of Fish,

WITH

OTHER DOCUMENTS.

BOSTON:

WILLIAM WHITE, PRINTER TO THE STATE.

1857.

SENATE....No. 193.

Commonwealth of Massachusetts.

EXECUTIVE DEPARTMENT, COUNCIL CHAMBER,
Boston, May 6, 1857.

To the President of the Senate :—

I transmit, herewith, for the use of the legislature, the Report of the Commissioners, appointed under Resolve of 1856, chapter 58, concerning the Artificial Propagation of Fish.

HENRY J. GARDNER.

Commonwealth of Massachusetts.

BOSTON, May 5, 1857.

SIR:—I have the honor to transmit, herewith, to your Excellency, the Report of the Commissioners appointed under the Resolve of the legislature, passed May 16, 1856, respecting the Artificial Propagation of Fish, and accompanying documents. Also a statement of the accounts of each of the Commissioners, for their services and expenses.

With great respect, I am
Your Excellency's o'bt serv't,

R. A. CHAPMAN.

His Excellency, HENRY J. GARDNER, *Governor of the Commonwealth of Massachusetts.*

Commonwealth of Massachusetts.

To the Honorable Senate and House of Representatives of Massachusetts in General Court assembled.

The subscribers, having been appointed commissioners under a legislative Resolve, passed on the 16th day of May last "to ascertain and report to the next General Court, such facts, respecting the artificial propagation of fish as may tend to show the practicability and expediency of introducing the same into this Commonwealth, under the protection of law," respectfully submit the following

REPORT:

Their commissions having been issued on the 16th of June, they did not meet till the first week in July. At that meeting they were informed, that they were expected, not only to ascertain and report such facts, respecting the artificial propagation of fish, as had already been made public elsewhere, but such as they might ascertain by actual observation and experiment, within the limits of this State.

The sum appropriated to this object by the Resolve, seemed to indicate that such experiments were contemplated, though on a limited scale. As Mr. Atwood has been all his life a practical fisherman, and has also become a learned ichthyologist, his associates in the commission, deemed it their duty to intrust him with the sole charge of making such observations and experiments, as the season would permit.

At a subsequent meeting, held in August at Provincetown,

it was agreed, that he should confine his attention to trout, and that he should proceed, either to Sandwich or such other place as he might select, as soon as the spawning season should approach, and devote as much time to the subject, as he might think proper. This was all that could be done, there being no other species of fish, whose spawning season would permit experiments to be made before the Commissioners were required to report. Nor did the Commissioners suppose that experiments, with any other species of fish, could be necessary; for if the spawn of trout can be fecundated and hatched by artificial means, it is obvious that similar processes may be applied to the spawn of other fish.

Guided by such knowledge as could be obtained from books and other sources, Mr. Atwood commenced his observations on the 13th of September, and has made a report on the subject which is herewith submitted. It may be sufficient to remark in relation to it, that though he did not succeed in hatching any eggs, yet he was successful in producing their fecundation, and has thus demonstrated its practicability, and he was also able to observe the growth of the fishes till they died just before the time for their hatching.

The Commissioners take pleasure in expressing their obligations to Professors Agassiz and Wyman, who have favored Captain Atwood with advice and instruction, in respect to his course of proceeding.

We have also collected such information, on the subject of fish breeding, as we found accessible, and are happy to find that it has attracted so much attention elsewhere, as to render any further experiments at the expense of the Commonwealth, unnecessary. Nor can it be necessary, that the Commissioners should give any detailed account of the processes adopted in breeding fish, since those who may be interested in the subject can find all the information they need, in books that can be readily obtained. In 1854, a small volume which is sold for about seventy-five cents, was published by the Messrs. Appleton of New York, entitled "a complete treatise on artificial fish breeding, including the reports on the subject, made to the French Academy and the French government, and particulars of the discovery as pursued in England; translated and edited by W. H. Fry." The Commissioners would recommend to

those, who desire information in respect to fish breeding, to purchase, either this volume or another to which they will also refer.

In the Agricultural Year Book, for 1856, by D. Ames Wells, pp. 347–50, the Commissioners found an interesting article, containing an account of some experiments made by Drs. Ackley and Garlick, of Cleveland, Ohio. The perusal of this article induced the chairman to address those gentlemen, asking for further information in respect to their operations. Dr. Garlick kindly replied, informing us that he was preparing a work on the subject, and that he would furnish us with some of the proof sheets, in season to enable us to refer to them in our Report. These sheets were not received, until the 12th of April, and our Report has been delayed on that account. So far as the Commissioners can judge, from the portions which have been received by them, they believe it will be preferable to the work of Mr. Fry, inasmuch as it contains an account of experiments which have been instituted in this country. We suppose the volume will be issued in a short time. The following extract from pp. 18, 19, contains an account of the process of artificial fecundation.

"The following directions, if strictly adhered to, will be crowned with success in the hands of any one:—

"The eggs of fish are not sufficiently matured to be successfully impregnated until the fish is engaged in depositing the eggs; therefore, no attempt should be made to extrude the eggs artificially until the fish has been seen or known to deposit them; but they should be extruded as soon as possible after the fish has commenced depositing them, for the reason that more eggs can be secured.

"The parent fish should be taken with nets while on their spawning beds; the size of the nets will, as a matter of course, depend upon the size of the stream, or other waters, where the fish are engaged in spawning; for small trout streams, the common landing net of the angler is sufficiently large.

"After one or more pairs of fish are thus taken, they should be placed in a tub or bucket of water; the female is then to be held in the left hand, and a gentle pressure made with the right hand upon her abdomen. At the time of the pressure, the

right hand should be carried downward; if the eggs are mature, they will flow from the fish with a very slight pressure, and are to be received in an earthen vessel, partly filled with clean water; then treat the male fish in precisely the same manner. The spermatic fluid from the male being received into the vessel, containing the water and eggs, the eggs should then be stirred about very freely in the water, and suffered to remain ten or fifteen minutes, when the water should again be changed, and after a short time this change should be again repeated. It is thought by some persons, that the eggs should be stirred or rinsed, and the water changed before the spermatic fluid is added. The precaution, I think, is a good one, as it serves to remove any mucus, with which the eggs are more or less covered, and which, to some extent, may prevent a perfect contact of the sperm with them.

"A very small portion of the spermatic fluid is sufficient to impregnate the eggs of one female; in fact, the sperm of one male is sufficient to impregnate the eggs of half a dozen females."

Chapter 2d contains directions for the treatment of the eggs after fecundation. It is very simple, and the apparatus is cheap and easily constructed by any man of ordinary ingenuity. Chapter 3d contains directions for the transportation of the fecundated eggs, and it has been found that they can be carried to great distances. The French government has an establishment for the artificial propagation of fish, from which the spawn are carried to every part of the empire, and to most of the adjoining countries, and it is not doubted, that they may be transported across the Atlantic, without injury.

The experiments of Messrs. Ackley and Garlick, commenced in 1853. Having in their possession a large spring of living water, near the city of Cleveland, they formed an artificial pond by means of a dam, and placed in it about one hundred and fifty trout, which they brought from Lake Superior. They afterwards procured about forty more from Port Stanley in Canada. From this beginning, they have proceeded with complete success; and other gentlemen in their neighborhood have procured trout from them, and commenced the business of fish breeding. It cannot be necessary to lengthen this Report by any further notice of these operations, for any person desiring

full information in respect to them, will not fail to purchase the book.

A few weeks since, the attention of the Commissioners was called to an article in the newspapers, containing an account of experiments made in fish breeding by Mr. E. C. Kellogg, of Hartford. The chairman was induced to call on Mr. Kellogg, and takes this occasion to express his obligations to that gentleman for his kind attentions. Mr. Kellogg commenced his operations in 1855, at a small spring in Simsbury, and succeeded in raising a few trout by artificial breeding. Last fall, not having time to devote to the matter, at such a distance from home, he constructed a small apparatus in his cellar, and supplied it with a small rill of water from the pipe of the city aqueduct. The water of this aqueduct is supplied by the Connecticut River, and has proved to be of excellent quality for the purpose. Mr. Kellogg has a considerable number of trout which have been hatched so long as to have cast off their umbilical sack, commenced taking food, and taken the familiar form and assumed the familiar habits of trout. He has others that are but just hatched, and have the appearance described in the books. He has also a quantity of trout which he caught with a hook and placed in a tub in his cellar, where he has made interesting experiments in respect to their food. Among other things, he has found that leaving the meat he has given them to putrify in the water, does not affect their health injuriously. Mr. Kellogg has lately addressed a letter on this subject to H. A. Dyer, Esq., Secretary of the State Agricultural Society, which will soon be published by the Natural History Society of Hartford. It is to be hoped that he will furnish the public, through the press, with further accounts of his experiments. We cannot doubt that the opinion expressed by him is correct, viz.: that any man of ordinary intelligence may engage successfully in the business of artificial fish breeding, but that it needs some experience, which books cannot supply. No one need be surprised, if some of his first experiments should prove to be failures.

For further information contained in books on the subject, the Commissioners would refer to various numbers of Silliman's Journal of Science; especially to the numbers for May, July, and September, 1853, May and July, 1855, and March and

May, 1856. The scientific annual by D. A. Wells also contains, in several of the volumes, brief articles on the subject. We also found an article on Pisciculture in the Revue des Deux Mondes for June 15, 1854, by Jules Haimes, containing an excellent history of the subject, with many valuable observations. Not having leisure to translate it, the task was kindly undertaken and performed by Mr. Gamaliel Bradford. As the publication of this article appears to us to be desirable in order that full information may be spread before the public, we transmit it herewith, in order that the legislature may make such use of it as they may think proper.

Several years since, a work was published in France by M. Coste, from which the American writers have derived much of their information. A new and improved edition of that work was published in 1856, but we believe it has not been translated. It can be easily obtained through importing booksellers. Its instructions, in respect to the transportation of fish for breeding, the transportation of spawn, the preparation of spawning beds, and the keeping of fish in inclosures, deserve attention.

The report of M. Millet to the Societié Impériale Zoologique d'acclimatation, in March, 1856, contains valuable suggestions in respect to the planting of trees on the borders of streams where fish are raised.

In France, the artificial propagation of fish was commenced by two illiterate fishermen a few years ago. Their wonderful success soon attracted the notice of men of science, and afterwards of the government; and it is now regarded as a matter of great public concern. Information has been collected and experiments have been made at the public expense in respect to every variety of valuable fish, to be found in their fresh waters, and very recently attention has been directed to the multiplication of various species of marine fish, on and near the sea shore. It is found that the supply of food from this source can be greatly increased.

In this country, the supply of food is so abundant, that the preservation and improvement of the fisheries in our fresh waters, has been much neglected. The increase of our population for half a century or a century to come, will be likely to give to them a new importance. Even now, we have found a much greater interest in them than we had supposed to exist.

Massachusetts abounds in streams suitable for trout; and from many of them, large quantities are taken every year. But there are very few instances, where the owners of the lands over which the streams flow, take any pains to preserve or to multiply their stock of fish, or even to claim them as their property. An implied license is given to all persons to fish at their pleasure. Hence the stock of fish is greatly diminished and very few fishes grow to their full size. They are not regarded by their owners as valuable property, and fishing is pursued as a mere pastime.

But this state of things cannot last long. As wealth increases, trout are sought as a luxury, and they have already acquired a market value so great, that the proprietors of streams might profitably raise them for market. There are many persons who need rural exercise, and who would cheerfully pay a liberal rent to the proprietors of a stream, well stocked with trout, for the exclusive right of fishing. We believe there are many farms on the hilly and mountainous parts of Massachusetts, containing trout streams, that, with a little pains, might be made to yield a greater income in this way, than the land itself. Much might be done to increase their value without resorting to artificial breeding. The preparation of suitable ponds or pools of deep water, and of gravelly beds, suitable for spawning, with slight guards to prevent the destruction of the fish by freshets, would greatly increase the stock. But the process of artificial propagation, is so simple and easy, that when trout become an object of care, we cannot doubt that they will be multiplied and protected by this method. Many millions of fine trout may thus be produced annually, and what is now regarded as a mere temptation to waste time, may be made, not only to minister to luxury and health, but become an important branch of productive industry. In addition to this, fish ponds with borders of trees and shrubbery add to the beauty of a landscape, and must increase the value of a farm.

The spawn of fish are so numerous, that the stock can be increased with immense rapidity; and by the exercise of proper skill, a large proportion of the spawn can be hatched. In England, out of 300,000 salmon spawn, 275,000 were hatched by artificial means.

Our large streams, and especially those whose current is com-

paratively sluggish, and which, on that account, are unsuitable for trout, might be made to yield a large stock of various other species of marketable fish, such as are adapted to their waters. Those large ponds and reservoirs, which have been created to supply water-power to our numerous manufacturing establishments, might all be turned to a profitable use in this way. It has been suggested that some of the species of excellent fish that are found in our Western lakes, would thrive in these waters. The variety might also be increased by the importation of eggs from Europe. In many of them, nothing needs to be done but to increase the quantity of fish they already contain by artificial propagation, and by protecting the young fishes from destruction, till they become sufficiently large to protect themselves against their enemies.

The fisheries of the Merrimack River having been made the subject of investigation during the present session, we need not refer to them particularly. An intelligent gentleman has estimated their value at $16,000 annually; the fish consisting principally of bass, shad and alewives.

In the Connecticut River, shad and salmon were formerly very abundant. The salmon disappeared many years since. The shad still continue to ascend the river, as far as the artificial obstructions will permit them to go. When the dam of the Hadley Falls Company was erected at Holyoke, a few years since, the company purchased and extinguished all the fishing rights above that point. But the shad still continue to ascend to the foot of the dam, where they are taken in considerable numbers, and they are said to have numerous spawning beds between that point and the head of Enfield Falls. But the proprietors of the locks and canals at Enfield, have so far obstructed their ascent within two or three years past, that it is believed they will soon leave the river entirely, unless something is done for their preservation. This obstruction may be obviated without much expense, and it is believed that, by means of artificial propagation, the river below Hadley Falls, might be vastly better stocked with shad than it has ever yet been. An establishment for this purpose might be erected in this State, and the mouth of the Agawam River has been spoken of as a very suitable place. It is believed that these fish always return from the sea

to the river where they were hatched. The ascent is at their spawning season, and they are then in the best condition for use.

Those which are taken for market within the limits of this State are generally in such a condition that their spawn and milt may be used for artificial fecundation. It has been estimated by persons who are acquainted with the shad fishery of this river, that by means of artificial propagation the number of shad taken in the river might be increased by one or more millions annually; and as the fish are sold for about twenty cents each at the landing places, the value of such an increase would be very great. This improvement in the fishery cannot be made without joint legislation on the subject in this State and in Connecticut. Probably a general Act of incorporation which should give a fair proportion of the profits to all persons engaged in the fisheries, from the mouth of the river upwards, would be the most effectual encouragement that these fisheries could obtain from legislation. It would not be difficult to frame an Act which would be just to all persons interested, and which would enable them to maintain an establishment for the artificial increase of the fish at the expense of all in proportion to the value of their respective rights of fishing.

It is also believed by many intelligent persons that the river might be again stocked with salmon by such a company. But legislation would be of no avail unless it were sought for by the proprietors of the fisheries, and concurred in by both States.

One branch of the inquiries to which our duty has directed us, relates to the necessity of further legislation. In considering this subject, we could not fail to remark the contrast that exists between the policy of our own government and that of France. There the government extends its supervision of property and business to the most minute particulars, while here every thing is left as far as possible to individual enterprise; and our policy is to protect and promote industry with the least possible amount of legislation. And therefore, while the legislation of France, in respect to the fisheries, exhibits great learning and skill, it is not at all adapted to our circumstances.

So far as trout streams are concerned, no legislation appears to us to be necessary. Each proprietor of land is also the proprietor of the fisheries upon it. The law protects him against

trespassers and thieves, and so soon as it is understood that the owners of the fisheries consider them valuable and intend to exclude other persons from the use of them, their rights will undoubtedly be respected. We cannot recommend any addition to our penal laws till it is called for and found to be necessary.

In respect to extensive ponds, bordering on a great number of proprietors, and also in respect to large streams flowing through the lands of a great number of proprietors, and in which the passage of fish from one portion of the stream to another cannot be prevented, some legislation would doubtless be proper. It occurs to us that Acts incorporating the proprietors of fisheries, somewhat resembling the Acts incorporating the proprietors of general fields, may be suitable. These acts might confer exclusive rights of fishing upon the riparian proprietors, giving to all of them an opportunity to become members of the corporation. If a part of the riparian proprietors decline to avail themselves of the privilege, they should not be permitted to prevent the use of the waters by the others. The laws which justify the flowing of lands for mills, and the taking of lands for aqueducts and other similar purposes, will justify such an appropriation of our fisheries. There is no other method of securing to those who engage in the labor of stocking our waters with fish the benefit to which they are entitled.

But we do not think it proper that any general law should be passed on this subject. We are without experience to guide us, and probably it would be necessary that legislation should be adapted to each particular case, in order to secure the rights of all concerned. Whatever charters are granted should also be subject to modification, so that if errors are committed, they may be corrected. And no legislation can be of any avail until private enterprise shall ascertain its own wants.

If the State shall be disposed to encourage this branch of industry while it is new, by means of legislative bounties, we would suggest that the agricultural societies of the several counties may be very suitable agencies to be intrusted with the business.

In view of all the information that we have been able to obtain, we have arrived at the following conclusions, viz.: that the artificial propagation of fish is not only practicable but may be

made very profitable, and that our fresh waters may thus be made to produce a vast amount of excellent food; that a small outlay of capital and a moderate degree of skill, aided by such information as can be derived from books that any man can procure, will enable the proprietors of our smaller streams and ponds to stock their own waters; that in respect to the larger streams and ponds, a combination of individuals may be necessary, with special legislation adapted to each particular case, and guarding the rights of all persons interested in the waters, especially when they have been applied to mechanical purposes; and that in all other respects, so far as the Commissioners can see, our laws afford to this branch of industry all the protection that can be necessary. If, indeed, any legislation were supposed to be necessary, it would be premature at present. Hasty and inconsiderate legislation is more likely to be mischievous than useful. All laws should be based upon practical knowledge; and in our opinion there is too little practical knowledge on this subject in the Commonwealth to authorize any changes in our existing laws.

There is a kindred subject in respect to which legislative inquiry may be useful, and the Commissioners are indebted to Prof. Agassiz for suggesting it. The suggestion is based on the fact that some kinds of fish are brought to market at seasons when they are unfit for use. Trout and salmon, for example, are sent to Boston market, from Maine and elsewhere, as mentioned in Capt. Atwood's report, at their spawning season in the autumn, when they ought to be left undisturbed, and when they are unfit for food. The same practice is said to exist in respect to some other species of fish. Such sales in market ought to be prohibited by penal laws; but as a preliminary step, a careful inquiry should be instituted into the facts by competent persons. The Commissioners have not considered such an inquiry as being within the range of their duties.

R. A. CHAPMAN,
HENRY WHEATLAND,
N. E. ATWOOD,
Commissioners.

Commonwealth of Massachusetts.

To the Hon. R. A. CHAPMAN, *Chairman of the Commissioners.*

At the time of receiving the appointment of Commissioner for the Artificial Propagation of Fish, the season had so far advanced that nearly all the fresh water fish had deposited their spawn, with the exception of the trout and the allied species. Under these circumstances, it was deemed advisable that I should direct my inquiries to the trout,—respecting the habits, time of depositing the spawn, localities where found most plentiful, &c. From the best information which I could obtain, Barnstable county was selected as containing the best trout streams.

On the 13th of September, (with the advice, consent and approval of my colleagues in this commission,) I went to Sandwich, and located there, for the purpose of observing the habits and experimenting on the artificial propagation of this fish. On the 15th of September I obtained four specimens—two males, two females—and found that the eggs were not mature; carefully observing the condition of those that were taken from that date, no mature eggs were noted until the 3d of November, when some were obtained and fecundated by artificial means. This was effected in the following manner. I took a zinc vessel and put into it about one pint of clear water; then taking the female fish whose eggs were mature, holding her over the vessel and gently passing the hand over the abdomen, the eggs freely passed from the fish into the water I then took the male fish whose milt was mature, holding him over the vessel in the same manner, pressed the milt into the water containing the eggs; the water was stirred gently with the hand so that every part of

the egg came in contact with the milt; after the lapse of two or three minutes, the water was poured off, and some fresh water added; the eggs, by this means, were successfully fecundated.

By careful observation, I have ascertained that the trout commence to deposit their spawn about the first of November, and as late as the middle of December I have found the females with spawn. I think that the spawning season continues at least two months. I have observed in the Boston market, trout shipped from the State of Maine, in November, and their eggs were mature. At this season of the year this fish is exceedingly poor and lean, and consequently, as an article of food, it is considered of little value; when in good condition, they are very excellent, and find a ready sale at high prices. The common salmon also finds a ready sale at very high prices in the spring and early summer; at that time they are in excellent condition, and, like the trout, as the spawning season approaches, they become very poor, and remain so until long after they have deposited their spawn; during this time they are of little value as an article of food. In November last, some ten thousand pounds of salmon were shipped to the Boston market from the British Provinces, and sold at a low price. These were the first which I have ever noticed to be shipped to Boston at the time of spawning; they were full of mature eggs.

The trout, at the time of spawning, will not bite at the hook as well as at other times, but are taken with difficulty. Their habits, at this season, are to repair to the small brooks and streams where they can find a gravelly bottom, in order to deposit their spawn; at that time I could obtain a few with nets, and in no other manner; they were exceedingly scarce. I went to Plymouth, Barnstable, Marshpee, and the various streams and brooks in Sandwich to procure them, and finally, after much exertion, I succeeded in collecting some 15,000 eggs.

These, after having been fecundated by artificial means, were placed into small tanks or tubs, which had been partially filled with sand and gravel, and so arranged that a small continuous stream of water flowed in on one side, and passed over at the other, thus a constant gradual change of the water was preserved. At the expiration of twelve days, some of the eggs

were examined under the microscope, and it was perceived that the embryo had formed, and that the eggs were progressing hopefully. Soon after this time I noticed that some of the eggs began to rot; these were daily removed, as they were easily detected by becoming opaque—the healthy eggs being perfectly transparent. The rotting of the eggs continued to an alarming extent, so that at the expiration of fifty-five days only a few remained. The embryo had at that time become so far developed as to be distinctly seen by the unaided eye. I thought that a few of them might be saved by being put into still water. I accordingly brought to Boston the few that remained, and with them a quantity of water into which they had been deposited, deeming it not advisable to change the water suddenly, but gradually to replace it with the Cochituate. I also tried the experiment of placing some of the eggs into all Cochituate water, and they soon died.

The rotting, however, continued, and those that continued healthy appeared to be progressing hopefully until about the first of February; after that time I could not see any further development of the embryo; they had been deposited about ninety days, and the embryo seemed to be far advanced towards maturity. The cause of their final decay and loss must have been owing to the water not possessing the qualities their natures required. At Sandwich, where I made my experiments, there were two ponds, an upper and a lower pond, with springs running into the former; between the two ponds was a dam, that prevented the fish from passing from one to the other. In the upper one I found trout apparently of all ages, both young and old; but in the lower, below which I made my experiment, I found only a few trout, and they all had the appearance of extreme old age. In this pond I took five specimens, and they were females with mature eggs. I took the milt of males taken in other localities and put with the eggs, and fecundation did not appear to have taken place. I came to the conclusion that the trout in this (the lower) did not multiply, but that they were the fish that were in the pond when the dam was built.

After I found that the eggs which I had collected were fast decaying, I then (when it was too late to apply a remedy, or to adopt a different course,) concluded that the water was not

suitable for their development, and although a large quantity of water was flowing out of the pond where I was located, and from which I took the water, yet the bottom being covered with mud, which was constantly accumulating from year to year by the falling leaves, &c., might tend to render the water unsuitable for the development of the eggs of this fish.

In conclusion, I must be permitted to express my sincere thanks to Prof. Agassiz and to Prof. Wyman, of Cambridge, for their kindness in imparting information and advice in respect to the most suitable manner of conducting my experiment.

N. E. ATWOOD.

PISCICULTURE.

Fisheries have often been called the agriculture of the waters, as if seas, lakes, and rivers were inexhaustible store-houses of food, where, without fear of ever impoverishing them, man might continue to take and destroy forever, bounded only by his wants and his desires. This definition is false, because founded on a false view of the case. Fishery is not the agriculture of the waters; it is only the harvesting. The waters are a source of production extremely powerful, but by no means infinite, and that the harvest may be always certain and abundant, it should be prepared by regular sowing, if it is true, according to the expression of M. de Quatrefages, that fish may be multiplied by sowing in the same manner as grain.

This would appear unnecessary pains, if we were to consider only the very great fecundity of almost all the aquatic tribes. A perch of moderate size contains 28,320 eggs, and a herring 36,960.

Thomas Harmer [1] and C. F. Lund [2] have obtained by untiring researches, still higher numbers from other species, e. g., 80,388 and 272,160 for the pike; 100,360 for the sole; 71,820 and 113,840 for the roach; 137,800 for the bream; 383,250 for the tench; 546,680 for the mackerel. A carp, weighing three kilogrammes (66 pounds) contained, according to Petit, 342,140 eggs. A flounder has given the enormous figure of 1,357,400. There have been counted in a sturgeon as many as 7,635,200, and Leuvenhock has found 9,344,000 in a cod-fish. Finally, M. Valenciennes [3] has just calculated that there

[1] Philosophical Trans. Royal Society of London, Vol. lvii., p. 280. 1768.

[2] Memoirs of the Swedish R. A. of Sciences, Vol. xxiii., German Ed., p. 192. 1761.

[3] Valenciennes and Fremy. Researches on the Composition of Eggs in the Series of Animals. Academy of Sciences, March 20, 1854.

are 9,000,000 in a turbot of fifty centimetres, (19½ inches,) and as many as 13,000,000 in a thick lipped mullet.

If only the tenth part of the germs inclosed in the body of each fish arrived at maturity, there would be little to fear from the devastation of our coasts, or the depopulation of our fresh waters; but numerous causes of destruction tend to reduce considerably the multiplication thus richly provided for. These arise partly from natural causes, but in great part also, from the act of man. We are to point them all out, if possible, and weigh them successively before discussing the means of preventing their action, which will form the chief object of this article.

In the first place, we must not forget, that in the general harmony of nature, as Mr. Milne Edwards has justly remarked, the productiveness of animals is regulated with a view not only to the dangers to which the young are exposed before arriving at the age of reproduction themselves, but also to the uncertainty of fecundation of the eggs. It is well known that the immense majority of fishes are oviparous, and that the fecundation is effected by the operation of the male element upon the female element separate from the body of the animals, and in the midst of the waters where they live. This action is the condition necessary to the development of the embryo, and all the eggs, which have not experienced the contact with the animalcules of the milt, change and soon decay. Now it is never the case that all the spawn receives this action, and from this cause alone a portion, more or less considerable, is always lost. The portion which remains is in turn exposed to a host of pernicious influences. It may be left dry by a decline in the level of the water, or spoiled by the slimy substances which a rise of the waters always causes and carries with it. The spawn has also numerous enemies; many fish devour it, many crustacea, many insects attack it in like manner; it may be carriedo ff by sea-weed and byssus, and almost all aquatic birds are very fond of it.

All these chances of mortality and destruction prevent the fish from increasing as fast as the great number of eggs would at first lead us to suppose, but they are still in a measure subject to the laws of the animal creation, and would seldom suffice for the depopulation of the waters, unless supported by causes of another nature. Among these should be mentioned, first of

all, the inadequacy of the legislation on the fisheries, and the violation with impunity of all the protecting ordinances which it has provided.

At the end of the last century Duhamel pointed out the depredations of the fishermen, who cast their lines with impunity at all seasons of the year, and daily suffer numbers of fishes, too small to be sold, to perish upon the banks. He saw, with natural indignation, the inhabitants of the coasts fill baskets with the spawn to manure their land or feed their swine. This culpable improvidence has still further increased, and we can almost say that at the present time all injuries are authorized, and all abuses are practiced, without limit. In vain the best grounded complaints are raised against the poachers upon fisheries; the devastations have continued on all sides.

The necessity has been felt, however, for a long time, of taking repressive measures against the destruction of spawn, and the historians of fishery have collected numerous ordinances, which have been successively issued with this view at different times and in different countries. Without citing them all, it will be sufficient to recall those which have had the greatest influence upon the legislation of the present time. In the year 966, Ethelred II., king of the Anglo Saxons, interdicted the sale of young fishes. Malcolm II., in 1030, fixed the time of the year when the salmon fishery should be permitted. Several other kings of Scotland have confirmed these decrees. Under Robert I., the willows of the bow-nets were to be separated by at least two inches of interval, to leave a passage for the young fry. In 1400, Robert III. carried severity so far as to punish capitally every person convicted of having taken a salmon in the forbidden season. This cruel law was abolished by James I., but this prince kept up the interdict during the same season, and every infraction still remained the object of severe penalties. The kings of France were at great pains also to insure the free development of the young fishes. A great number of ordinances were issued by them, to determine the nature of the nets, of which the use should be permitted, and the length of the fishes which might be sold in the market places. At length, in 1669, Colbert placed upon a new footing the legislation of the coasts and rivers. He prohibited river fishing during the night and during the spawning season, under

penalty of a fine of twenty livres and a month's imprisonment for the first offence, of a fine double in amount and two months' imprisonment for the second, and of the pillory and the scourge for the third. The only exceptions were in the fisheries of salmon, shad, and lampreys. Colbert also prohibited the placing basket work at the end of the drag nets during the spawning season, under penalty of twenty livres fine, and after having determined the kinds of snares to be forbidden, he directed that the fishermen should return to the streams the trouts, carps, barbels, breams and millers, which they should take having less than six inches between the eye and the tail, and the tenches, perches and mullets having less than five inches, under a penalty of one hundred livres fine.

The legislation which governs us at present is based upon the previous dispositions; unfortunately, it has disregarded the information offered by natural history, and thus but imperfectly attains the object proposed. The regulations relative to marine fishing, permit, for example, the taking of a given fish on shores where it has never been found, and give, for the limit of the crustacea, indications contrary to the most simple common sense. The code of river fishing, which principally interests us here, is no better protected against criticism. The ordinance of November 15, 1830, supplementary to that of April 15, 1829, leaves to the prefect of each department the care of determining, with the advice of the general council, and after having consulted the foresters, the times, seasons and hours when fishing shall be prohibited in the rivers and water-courses. Now how many times must the prefects, little skilled in natural science, or ill advised by those whose duty it is to enlighten them, have committed errors like those of Colbert, when he interdicted trout fishing from the first of February to the middle of March, that is to say, at a time when they had nearly all already finished spawning! The same ordinance prohibits certain specified nets and snares, thus intimating that all others are authorized, and permitting changes of form and name in the first, without rendering them less formidable or destructive. Article 30 of the fishery code punishes, with a fine of 20 to 50 francs, whoever shall catch, offer for sale, or sell fishes of less than the prescribed size, but it excepts from this provision sales of fish coming from ponds or reservoirs. It will at once be perceived how easy

it is, through this exception, to catch and sell fish of all sizes. Article 24 forbids the placing of any gate, structure or fishing establishment whatever, calculated to prevent entirely the passage of fish, but it tacitly authorizes dikes and mill dams, which produce the same effect.

We will carry criticism no farther. It would be as easy for us to show that no efficacious measures insure the action of the fish police, and that the law is as badly executed as conceived. This state of things is deplorable, and has, without doubt, powerfully contributed to bring on the decay which has fallen upon the aquatic industry of France.[1]

Some figures, taken from the archives of the ministry of finance, will show clearly the importance of the evil. The water-courses of France have a total length of 197,255 kilometres (122,500 miles.) Its lakes, reservoirs and fish ponds occupy a superficies of 220,000 hectares (900 square miles.) Now the rent of all the waters directed by the commissioners of forests, and those of dikes and bridges, yields to the State a revenue of 660,000 francs. The former alone give fishing privileges in 7,570 kilometres (4,750 miles) of navigable and floating water-courses, producing the annual sum of 521,395 francs; that is an average of 69 francs to the kilometre. The insignificance of this sum is very striking, when compared with what it ought to be, or even with that still furnished by some rivers more favored than others. Thus the Doubs, in the Jura, is still let out at the rate of 159 francs the kilometre. The Moselle, in the department of La Meurthe, at the rate of 182 francs. For a similar length, the Loire brings in 252 francs in La Loire Inferieure, (department,) the Sarthe 297 francs in Le Mairie et Loire, and the Loiret 309. La Mayenne produces 339 francs, and the Seine 498. As for the Mairie, it produces the exceptional sum of

[1] The evil has been further increased by the encroachments of manufacturing industry, as well as by the processes which they have involved. The mills throw off into the water-courses their acids and salts, which have become useless, and the bleachers do the same with their chlorides. The beds of streams have often to be laid dry to execute dragging and cleansing. Finally, steamboats, by their violent movements of the water, raise and cast up the young fishes upon the river banks, and these are often retained and perish there. These last causes of destruction are still more fatal to the development of the fry than the culpable practices of the poachers.

1,378 francs. By the side of these figures, more or less satisfactory, many others attest, on the contrary, the extreme scarcity of fish. The Ain, in the Jura, produces only 14 francs to the kilometre; the Dordogne, in the department of La Corrèze, 10 francs, the Isère 8 francs, the Drôme 4, and the Durance 2. Finally, 219 kilometres have been depopulated to that point, that they cannot be let at any price.

This marked inequality in the revenues of several rivers, which offer in general similar conditions to the fish, or whose different conditions can be differently improved, seems to indicate that the evil, even where greatest, is not irreparable. The proprietors, injured by the impoverishment of the fisheries, and the government itself, more interested than any body in the products of the rivers, have yet remained a long time inactive under the laws which they are sustaining. The remedy has been decided upon only after the reiterated solicitations of naturalists, who, long since masters of a process of artificial multiplication, have felt that it might be usefully applied to the repopulating of rivers and ponds. The first experiments have given results sufficiently remarkable not to discourage farther attempts. The practical methods have been promptly developed, and scientific researches, skilfully conducted, have impressed a new character upon pisciculture—that is, the branch of rural economy which is occupied with the improvement of waters. A very general interest is now felt in this important question of the artificial multiplication of fish, which belongs at once to the natural sciences, to agriculture and to political economy. The result of the experiments which, since the end of the last century, have had for their object the re-stocking of rivers, already forms a curious chapter of zoological history, and while awaiting its increase by some new pages, it appears to us desirable to reunite its scattered elements.

I.

The first attempts at pisciculture were made by the Chinese and the ancient Romans, and it is probable that they were preceded by their elders in civilization. We have no positive data as to the epoch in which the Chinese commenced these experiments; but every thing tends to show that they reach back to

the most remote antiquity. We find in the "*Histoire Generale des Voyages*" (1748) in Grosier, in Davis, as M. Chevreul has already pointed out, and in most of the works which treat of Chinese customs, some curious details on the transport of the spawn of fish. According to the missionaries who have visited China, a multitude of salmon, trout, and sturgeons mount into the rivers of Kiang-si and into the ditches which are dug in the middle of the fields to preserve the water necessary to the production of rice. They deposit their eggs there, and the young, which are soon hatched, are a source of considerable profit to the riparian proprietors. The jesuit father, John Baptiste Duhalde, is the first French author who has shown[1] the manner in which this traffic is effected. We give his account, which most historians have copied with alterations: "In the great river Yang-tse-kiang, not far from the city Kieon-king-fou, in the province of Kiang-si, at certain times of the year, are assembled a prodigious number of boats for the purchase there of the eggs of fish. Towards the month of May, the country people bar the river in various places with mats and hurdles, for a length of about nine or ten leagues, leaving only sufficient space for the passage of the boats; the eggs of the fish are stopped by these hurdles. They can distinguish them by the eye, where other persons see nothing in the water; they draw out this water mixed with eggs, and fill several vases with it for sale, which causes, at this season, numbers of merchants to come with their boats to buy it, and transport it into different provinces, taking care to agitate it from time to time. They succeed one another in this operation. The water is sold in measures to all those who have fish preserves and domestic ponds. After some days there are seen in the impregnated water, as it were, little heaps of fishes' eggs, without its being yet possible to distinguish the species. It is only with time that this appears. The profit is often a hundred fold more than the outlay, as the people live in great part upon fish." To these very simple, but successful means of replenishing their ponds, the Chinese are said to have joined others which travellers have only very imperfectly indicated; they assert that when the young fish begins to eat, they give him marsh lentils mixed with yellow of eggs.

[1] History of the Chinese Empire, Vol. i., p. 35. 1735.

The Romans had nearly similar customs, at a very early epoch. "The descendants of Romulus and Remus," says Columella,[1] "rustics as they were, had much at heart the procuring upon their farms a sort of abundance in every thing like that which reigns among the inhabitants of the city; thus they were not satisfied with stocking with fish the ponds which they had constructed for this purpose, but carried their foresight to the point of filling lakes formed by nature with the spawn of fish which they threw into them. In this way the lakes Velinus and Sabatinus, as well as the Vulsmensis and Ciminus, have, in the end, abundantly furnished, not only cat-fish and gold-fish, but, moreover, all other sorts of fish which are able to live in fresh water." These practices were early abandoned, and it is a matter of surprise, when we consider the strange infatuation of which fish became the object in ancient Italy during the following centuries, that no measures were then taken to insure their reproduction and free development. It is well known that the ancients had a remarkable predilection for this species of food. The principal luxury of the Roman banquets consisted of fish, and the poets speak of sumptuous tables spread with these exclusively. In the period between the taking of Carthage and the reign of Vespasian, this taste became a perfect passion, and for its gratification the senators and patricians, enriched by the spoils of Asia and Africa, incurred the most foolish expense. Thus Licinius Murena, Quintus Hortensius, Lucius Philippus, constructed immense basins, which they filled with the most rare species, and Lucullus, like a new Xerxes, caused a mountain to be pierced to introduce sea water into his fish ponds. Varro[2] relates that Hirrius received twelve millions of sesterces ($675,000) from the numerous buildings which he possessed, and that he employed the entire sum in the care of his fishes. The rich patricians, says the same author, were not satisfied with a single pond; their fish preserves were divided into compartments where they kept shut up, apart from each other, fishes of different kinds; they retained a great number of fishermen solely to take care of these animals. They tended their fish as carefully as their own slaves during sickness. It is even

[1] De Re Rustica, Book viii., Section 16.
[2] De Re Rustica, Book viii., Section 17.

added that a naval expedition, commanded by an admiral, had for its object to introduce upon the coast of Tuscany a sort of scar peculiar to the waters of Greece.[1]

This extravagant fashion, which spread through the various classes of society, and brought on the ruin of entire families, had also the effect of impoverishing the coasts of the Mediteranean. Ismeral complained that time was no longer given to the fish of the Tyrrhenian sea to come to maturity. The scandalous luxury displayed in fish preserves, and the unwearied attention then directed to marine animals, have furnished no other result useful to pisciculture. The only fact worthy of remark at this epoch of sterile extravagance, is the introduction of gold-fish into artificial ponds, where shell fish were also placed for their nourishment.

We may pass rapidly over the immense interval which separates the Roman Empire from the eighteenth century, without remarking any important progress in the husbandry of the waters. The fisherman's art was, however, extended and perfected during the middle ages, and fish preserves became extremely numerous in France and Italy. Kings and princes all had artificial ponds in their domains, and we behold Charlemagne himself taking great pains to keep his own in repair, causing new ones to be dug, and giving orders that the fish produced should be sold. The religious communities exacted enormous duties upon almost all fisheries, and had considerable preserves in which multitudes of fish grew fat. The maintenance of these preserves required many precautions, and the restorer of agriculture in the thirteenth century, (Peter of Crescenza,) pointed out the manner of getting the greatest result from the lakes of fresh, as well as salt water. There appears in his work, however, no method worthy of being noticed here, and the treatise does not appear to us to have rendered any more service to pisciculture than that of Florentinus, in the third century, at least as far as we can judge of the latter by the extracts which Cassianus Bassus has preserved for us. It appears, nevertheless, that towards the end of the middle ages new methods were sought for which might serve to increase the

[1] For further details, see Noel de la Morimiere History of Fishes, Vol. i., 1815; Cuvier and Valenciennes Natural History of Fishes, Vol. i., 1828, and Dureau de la Malle, Political Economy of the Romans, Vol. ii., 1840.

production of fish ; a monk of the abbey of Réome, near Montbara, named Dom Pinchon, conceived the idea of artificially fecundating the eggs of trout, by pressing out in turn the products of a male and female of this species into water, which he afterwards agitated with his finger. After this operation, he placed the eggs in a wooden box, having a layer of fine sand on the bottom, and a willow grating above and at the two ends. The apparatus remained plunged, up to the moment of hatching, in water flowing with a gentle stream. This process is described in a manuscript dated 1420, and belonging to the Baron of Montgandry, grand nephew of our celebrated Buffon. It has never been published, and had remained secret till a recent time.[1] Dom Pinchon is then, in all probability, the first inventor of artificial fecundation, but his experiments must be looked upon as not having occurred, since they were not made public. They have of course had no influence on the progress of pisciculture, and are only interesting in a historical point of view.

The fishery of Commachio, on the Adriatic, of which the origin is probably very ancient, presents some natural features, which may, perhaps, be imitated with advantage on other parts of the Mediterranean shore. Already described at length by Bonaveri, then by Spallanzani, this lagoon still merits that we should say some words with regard to it. It is, perhaps, one hundred and thirty miles in circumference, according to Spallanzani, and is divided into forty basins surrounded with dikes, and all in communication with the sea. Eels abound there to such an extent, that the inhabitants sell them through all Italy. During the months of February, March and April, they leave the gates open and all the passages free ; the young eels enter of their own accord, and the more abundantly in proportion as the weather is stormy. This they call the "*mounting*." Once in the basins, the fishes find nourishment so abundant and so well suited to their wants, that they do not attempt to leave until full grown, that is, after about five or six years. The eels emigrate and are taken in the greatest number during the months of October, November and December. For this pur-

[1] M. De Montgandry explained the hatching box of Dom Pinchon at one of the last sessions of the Zoological Society of Acclimation, and was kind enough to inform us also of the manner in which the monk of Réome effected the fecundation of the eggs.

pose, the fishermen open at the bottom of the basins little passages bordered with reeds, which the eels follow from choice, and are conducted into a sort of narrow chamber, where they accumulate without being able to get out. On the average, the crop amounts annually to a million of kilogrammes, (2,204,737 pounds,) and M. Corte informs us that it produces, according to the estimate of M. Cuppari, a net revenue of 80,000 Roman crowns, that is, about $88,000.

The fishers of Commachio profit, as we see, by the advantages which nature offers, and they have but few precautions to take to insure the development of the fish in this great preserve. The less favorable circumstances in which the fisheries of the Swedish lakes were carried on, induced an investigation, towards the middle of the last century, of the means of preventing the considerable loss which the spawn had there to undergo. Already great care was taken in that country not to trouble the fish at the times of their reproduction, so that it was even forbidden to ring the bells during the spawning season of the bream. A counsellor of Linkoeping, Charles Frederic Lund,[1] remarked that the three species most esteemed among those which inhabit the lakes of that country, the bream, the perch and the mullet, attach their eggs near the banks, either to the rocks, or, by preference, to the twigs of pine and to the willow cages placed in the water to catch them. The eggs are thus destroyed by the fishermen, or devoured by insects, birds, and especially the fishes of prey, so that hardly one out of ten finally escapes. He well understood that the prohibition of fishing during the spawning season would very imperfectly prevent this enormous destruction. He devised another means of protecting the multiplication of the fish, which accords completely, as he himself remarks, with the habits of these animals, the mode and the laws of their reproduction, as well as with the rules of logic and of our own duty. He caused large wooden boxes to be made without covers, but pierced with little holes, and furnished with rollers, to allow of their descending easily into the water. He placed twigs of pine in them, and introduced a certain quantity of males and females, taken at the time of spawning, taking care

[1] Of the Planting of Fishes in Inland Lakes. Memoirs of the Swedish Academy of Sciences, Vol. 23, 1761. German Translation of Kartner, p. 184.

to separate them by their kinds and to give them space enough. After having left them there two or three days,—that is, during the time necessary for laying the eggs, he drew out all the fishes with the help of a small net, and arranged the boughs so as not to press too much against one another. The eggs arrived at maturity after a fortnight, or a little more, according to the degree of heat, and a multitude of young fishes came forth. This simple process included all the conditions necessary to success, and doubtless great advantages may be found in it for the propagation of fishes whose eggs are adherent. Lund succeeded in transporting from one lake to another, boughs covered with spawn, which he placed in a vase of water, taking care merely not to expose them to contact with the air. In making a first application of his process, he had put separately into three large boxes, with a small number of males, fifty female breams, which gave him 3,100,000 of the fry; one hundred perch of the large species produced 3,215,000 of the fry, and one hundred mullets gave 4,000,000 of little ones. He obtained then in this manner more than ten millions of young fishes, which were dispersed in the Lake of Raexen. If this process had been employed on a large scale in all the lakes of Sweden, there would have resulted, says he, a real blessing for the country.

The favorable circumstances of the arrangement adopted by Lund enabled him to observe some particulars of the development of the embryo. A German naturalist, Bloch,[1] advanced somewhat farther in this direction by employing a similar means. He took from the Spree some aquatic plants covered with eggs of perch, bream, rotengle, &c., and kept them in a wooden box of fresh water, renewed daily. At the end of a week he obtained many thousands of little fish; observing, however, that only a small part of the eggs were fecundated, and that those which were so remained transparent and yellow, while those which failed, become daily more disturbed and opaque. Bloch concluded that by transporting spawn upon plants, as he had done, lakes and ponds might be easily and cheaply stocked with fish; but he made no experiment, and as we see, only imperfectly imitated Lund.

[1] Marc Eliezer Bloch. General and particular Ichthyology, Part ii., p. 94. 1795.

While the ingenious predecessor of Bloch was seeking the means of increasing the inhabitants of the Swedish lakes, a lieutenant of militia of Lippe Detmold, in Westphalia, J. L. Jacobi, conceived the idea of artificially fecundating the eggs of fish and of applying this process to the repopulating of ponds and rivers. The curious results of his experiments were indeed embodied in a letter which the *Magazine of Hanover* only published in 1763;[1] but as early as 1858 Jacobi had addressed manuscript notes upon the subject to the illustrious Buffon, which Lacépéde has mentioned in the first volume of his *Natural History of Fishes*, and in the course of the same year he had intrusted another account of his labors to the Count de Goldstein, grand chancellor of Berg and Juliers. Goldstein caused a Latin translation of it to be made, which he sent M. de Fourcroy, director of fortifications at Corsica, and an ancestor of the celebrated chemist. This version was published for the first time in French in 1773, in Vol. iii. of the *General History of the Fisheries* by Duhamel-Dumonceau. Duhamel does not mention Jacobi, but the facts in both memoirs being perfectly identical and set forth in similar terms, it is impossible not to perceive that both writings emanate from the same author. The date of the first communication entirely secures the claims of Jacobi, which are besides confirmed by the quotations of Lacépéde, and by a communication made in 1764 by Gleditsch, to the academy of sciences at Berlin. We give the details, because the name of Goldstein alone having been printed in the *History of the Fisheries*, many naturalists have wrongly attributed to him the merit of the discovery of artificial fecundations.

The experiments of Jacobi were upon the two most esteemed species of fish, the trout and the salmon. He tells us himself that, before arriving at good results, he had to employ sixteen years in preparatory researches and incomplete experiments. He remarked, in the first place, that from the end of November to the beginning of February the trout come together in the brooks and fix themselves upon the gravel, where they rub their

[1] It is to be found also, *in extenso*, in Wm. Yarrell, History of British Fishes, Vol. ii., p. 87, 1841, and at the end of Practical Instructions upon Pisciculture, by M. Coste, 1853.

bellies in a way which leaves large tracks. The females then deposit their eggs, upon which the males drop their milt. He caused some trout, then, to be taken at this season, when ready to spawn; taking by turns a female and a male, he pressed their abdomen lightly over a vase half filled with water, and let fall into it the mature products of both sexes, and then stirred up the whole with his hand, in order to render the mixture more complete, and thus to insure the fecundation of all the eggs. These eggs being once fecundated, it was necessary to combine the circumstances proper for their development, and for this purpose Jacobi thought of placing them in a grated box, across a little brook of running water. He constructed a large chest, at one extremity of which, and on the upper surface, he left a square opening, barred by a metallic grating of which the threads were separated by a space of only about four lines; this opening served to let in the water. Another, grated in like manner, and placed in the vertical face of the other extremity, allowed it to flow out. The bottom was overlaid with an inch of sand or gravel. Jacobi placed this apparatus in a trench prepared for it by the side of a brook, or, better still, a pond fed by good springs, from which he could cause, by a canal, an uninterrupted stream of water to flow through the box.

These dispositions, very simple and judiciously combined, completely resolved the problem which he had proposed to himself, viz.: To protect the fecundated eggs against their natural enemies and yet to leave them in circumstances similar to those in which they would naturally have been placed. The experiment succeeded. After about three weeks, Jacobi saw appearing through the thick envelope of the egg two black points corresponding to the eyes of the animal, and eight days later he began to distinguish the body itself which moved and turned in the interior. Finally, after five weeks, the young fishes broke from their shells, and soon separated themselves completely from it, retaining only, under their bellies, a hanging yellow pouch, which is the umbilical vesicule. During nearly a month the young were nourished by the substance of this pouch, which disappears as they increase in size; but then they had need of other nourishment, and to obtain it, they left the box by passing through the grating, and fell into a reservoir filled with sand and fitted to receive them. Jacobi adds, that in a

basin of sufficient size, they grew wonderfully in the space of six months, and that then they had arrived at a suitable growth for stocking the ponds; but he does not say in what way he nourished them during all this time.

The inventor of artificial fecundation appears to have often repeated the experiments which he describes, and took great pains to insure the success of them. He perceived that the eggs are easily spoiled when they get into heaps, and recommends, to avoid this danger, the separating them frequently by means of a switch. Care should be taken also, that they do not stick together, when the milt is poured over them. Finally, the dirt which the water deposits should, from time to time, be carefully removed from them, and this may be readily done with the feather of a quill.

The question now is, Whether Jacobi, by neglecting no precautions, and guarding himself against the various chances of failure, did arrive at a final result which is completely satisfactory in a practical point of view? Did he succeed, by means of his process, in advantageously restocking water-courses which had become unproductive, or increasing production, to any extent, in those where fish were already abundant? We have not the requisite documents for answering this question positively; but we can scarcely doubt that he obtained at least partial results, since England recompensed his services with a pension, and in a little state of Germany, his operations have been continued with success by M. Schmittger.[1]

Physiology soon turned to account the discovery of Jacobi, and artificial fecundations have since been frequently reproduced in laboratories. There is no need of recalling the results which Spallanzani, Prevost of Geneva and Dumas, have drawn from them. They have been also a great help to embryological studies, and by employing this means two contemporaneous zoologists, Rusconi and C. Vogt, have been able to follow all the phases of development of the tench and the palie; but this discovery especially marked a great progress in pisciculture, and while science availed itself skilfully of this new mode of

[1] This fact is proved by a letter of Dr. Schutt, of Frankfort, recently written to Mr. Milne Edwards. The experiments of M. Schmittger have been made in the principality of Lippe Detmold.

investigation, the practical results obtained by Jacobi were carried out in Germany and Scotland.

In the *Treatise on the Economy of Ponds* (by Ernst Friedrick Hurtig, p. 411, 1831,) there is given a description of the process of Jacobi, with the remark that this method has been successfully employed by the forester, Franke at Steinburg, in the principality of Lippe Schaumburg, as well as by M. de Kaas, at Bückeburg. The same facts are confirmed by M. Knoche,[1] who asserts that he has himself also completely succeeded upon the estate called Oelbergen. The last writer placed the young fish at first in a little reservoir, and the following year transported them into a larger basin. "I have obtained by this process," says he, "in the eight years that I have been employed, 800 young fishes out of 1,000 to 1,200 eggs. After a year I found in the smaller pond only about half the fish, the others having either died or escaped. Apart from this loss they succeeded very well, and I have obtained in three years, out of the fish, in this manner, a crop of three to four hundred trouts a year, of three to four years of age, and of which the largest weighed three-quarters of a pound." M. Vogt, in a letter recently published, which reproduces this passage of M. Knoche, informs us at the same time that a decree of the government of Neufchatel, issued in 1842, gave complete instructions to the fishermen as to the method of artificially fecundating the eggs of fish.

Some experiments have also been made in England and Scotland. After having studied during several years the manner in which the salmon spawn naturally, Mr. John Shaw[2] attempted to combine the conditions, which appeared to him most essential, in some preserves which he caused to be made near the river Nith. These reservoirs were only two feet in depth, and spread with a thick bed of gravel. They were fed directly by the water of a spring which abounded with the larvae of insects. A close grating was placed before the conduits, by which the surplus of this water had to flow out to gain the river. These dispositions once made, Mr. Shaw fecundated the eggs just below the point where the water fell into his basins and left

[1] Journal of the Agricultural Union of the Grand Duchy of Hesse, No, 37, p. 407. 1840.

[2] Transactions of the Royal Society of Edinburg, Vol. xiv., p. 547. 1840.

them to develop at the same spot. This plan succeeded, and he was able to bring up a certain number of young salmon during two years, and even more. He took advantage of them to make observations upon their growth and change of color. At the age of six months the young salmon had a length of two inches; of a year, three inches and three-quarters; of sixteen months, six inches, and of two years, six inches and a half. At this last period, when they had put on the livery of emigration, and when they are called in Great Britain by the name of *parr*, the milt of the males had arrived at a sufficient state of maturity to be able to fecundate the eggs of adult females. We owe also to M. Shaw, as well as to Mr. Andrew Young[1] and Dr. Knox, our increased knowledge of various particulars relative to the monogamy of salmons, and to the manœuvres which the female performs on the spawning place, but these researches do not appear to have had any practical result worthy of attention.

An engineer of Hammersmith, named Gotlieb Boccius, published in 1848 a short treatise on the management of fish in rivers and streams. He extols in it the method of artificial fecundation, but without producing any positive fact to prove that he himself experimented with success. Since that time he has assured Mr. Milne Edwards that he had operated in 1841 upon the water-courses belonging to Mr. Drummond, near Uxbridge, then upon the estate of the duke of Devonshire at Chatsworth, upon that of Mr. Gurnie at Carsalton and that of Mr. Hibberts at Chalfort. Mr. Boccius must have raised already about two millions of little trout.

The discovery of Jacobi had passed successfully, as we have seen, the trial and application in England as in Germany. Up to 1848, nevertheless, France had remained very much behind in experiments of this sort. Although she, perhaps more than any other country, had need of effectual means for remedying the impoverishment of the waters, the French economists had given scarcely any attention to this question. A single one, the baron of Rivière, presented, in 1840, to the Central Society of Agriculture, some very learned and sensible reflections upon ichthyology regarded in its relations to the wants of man, and

[1] Natural History of the Salmon. Wick. 1848.

the profits of agriculture.[1] He insisted especially on the advantages which would result from taking in the spring the *bouirons* or little eels which abound at the mouths of rivers, and dispersing them in the lakes, ponds, pools, and even muddy ditches, where they live very well. He satisfied himself that they might be transported alive in casks full of water, without appearing to suffer much from it; but wherever it should be possible to use rivers or canals, he thought it better to make use of boats pierced with holes in communication with the water, such as are frequently used for keeping fish. In this memoir of M. de Riviére, the word Pisciculture is used for the first time; he employs it with hesitation to indicate this new branch of rural economy, which, says he, is still to be created.

II.

The year 1848 saw a new era commence in France for the economy of the waters. We believe it is just to say, that if the application of artificial fecundation to the repopulating of rivers is owing to a German naturalist, it is in our country that pisciculture has grown, has been perfected, and has finally come to constitute an actual branch of industry. All the progress which has been made within six years in this department of the science, is the work of French inquirers.

The first, M. de Quatrefages,[2] was led by purely scientific researches to occupy himself with the multiplication of fish. This zoologist, convinced that artificial fecundation would do away with the various causes which prevent the development of the eggs, advised the employment of the hatching box of Goldstein (or rather of Jacobi) for fish of running water. For those of ponds or lakes he recommended depositing the fecundated eggs on a layer of aquatic plants in a spot where the water should be tranquil and shallow, and protecting them by lattice work against the attacks of their enemies. He showed how the employment of the process discovered by Jacobi would facilitate the domesticating of foreign fish in our waters. Finally, he pointed out the possibility of rendering annual the

[1] Memoirs of the Central Society of Agriculture, Vol. xlviii., p. 171. 1840.

[2] Comptes rendues of the Academy of Sciences, Vol. xxvii., p. 413. 1848. See also the Revue des Deux Mondes. Jan. 1, 1849.

triennial and irregular product of the ponds by dividing them into three or four unequal compartments. In the smallest the eggs might be hatched and the fry raised. Each year the fish might be driven from one compartment to another, and the last basin might be fished every year.

The memoir of M. de Quatrefages made a good deal of noise, because it met one of the wants of rural economy, and gave a glimpse of a quite new prosperity for the industry of ponds and water-courses. Drawing from oblivion the results obtained in Germany during the last century, it recalled the attention of naturalists and husbandmen to a question too long neglected, and of which it would be now superfluous to dwell upon the importance. The author was, doubtless, far from thinking that the conclusions to which he had brought his studies would be almost immediately justified and confirmed by the experiments undertaken some years before, but which had not yet been made public. However, in the first days of March, 1849, the Academy of Sciences learned by a letter of Dr. Haxo,[1] Secretary of the Society of Emulation of the Vosges, that this society had, in the year 1844, given a premium to two fishermen of La Bresse, M. M. Rémy and Géhin, for having fecundated and artificially hatched some eggs of trout. M. Haxo added that Rémy and Géhin then possessed a piece of water containing five or six thousand trout, of one to three years old, all raised by this process. It is impossible not to admire the sagacity and perseverance of these fishermen, who, quite unlettered and ignorant of the progress of the natural sciences, have found the means of themselves, of remedying the decay of their industry, and of giving it a new impetus. Not only have they repeated, with great pains, the observations and experiments which occupied Jacobi's whole life, but they have gone much farther in the practical application, and have almost entirely resolved the problem.

Although they have both greatly contributed to the success of the undertaking, we now know that the first efforts were solely owing to Joseph Rémy, and that he associated Antoine Géhin with himself only after having already half succeeded. Rémy first studied the habits of the female trouts ready to spawn. He saw them remove the gravel with their tails, and

[1] Comptes Rendus of the Academy of Sciences, Vol. xxviii., p. 351. 1849.

rub their bellies to assist the laying of the eggs. Having caught many of them in this state, he perceived that by pressing them a little with his hand, he could easily force out the mature eggs, and that the same thing occurred with the milt of the males. He next suspended a female above a vase full of water, and by means of a light pressure applied from above downwards, he caused the eggs to fall out, upon which he afterwards poured, in like manner, the fecundating liquid of the male until the water was white. Next depositing the eggs in a tin box pierced with numerous holes, and spread with a layer of coarse sand, he placed the box in a fountain of pure water, or in the bed of a brook; after a certain time he saw the young hatched, and freeing their tails first.

These facts, which Rémy relates himself in a letter addressed in 1843, to the Prefect of the Vosges, are, as we see, almost identical with those which Jacobi has embodied in his memoir, as these last were with the experiments of Don Pinchon; but the two fishermen of La Bresse did not stop there.[1] It was not enough to have guarded the eggs against the chances of destruction, which menace them when abandoned to themselves. It was necessary also to insure the development of the young, and to find for them a nourishment suited to the wants of their age. This, Rémy and Géhin succeeded in doing. After two or three weeks of a diet adapted to these wants, they opened the boxes which contained the fry, and allowed them to run freely into a water chamber or a portion of the stream prepared to receive them. There they had taken care before-hand to raise a great number of frogs, of which the spawn is eagerly devoured by the young trout. Somewhat later, they had recourse to the method already employed for the support, in preserves, of adult carnivorous fishes.[2]

[1] Haxo d'Espinal on the Artificial Fecundating and Hatching of the Eggs of Fish, 2d edition, p. 22, 1853, and Guide of the Pisciculturist, 1854.

[2] "To nourish their young trout," says M. de Quatrefages, "they hatched with them, other smaller species of fish, smaller and herbivorous. These are raised and nourished upon aquatic vegetables. In their turn they serve for food to the trout, who are nourished by flesh. These fishermen have thus succeeded in applying to their industry, one of the most general laws, upon which are based the natural harmonies of the animal creation." In view of the necessity of their carnivorous diet, it is important to put together only trout of the same age, otherwise the smaller become the food of the large; and even with this precaution, it is not always possible to avoid the fatal effects of their voracity.

Rémy and Géhin first stocked two ponds near La Bresse, several brooks of their canton, the water-courses of the commune of Waldenstein, and have thrown about fifty thousand young trout into the Moselotte, one of the affluents of the Moselle. These results were too important, and promised too great advantages in the economy of our waters, not to draw the attention of the public, and even of the government. In 1850, M. Milne Edwards was officially charged by the minister of agriculture, to make sure of the accuracy of the facts published, and to ascertain their value. After having procured some information in England, as to similar experiments, he went into the Vosges, and visited the little establishment of the fishers of La Bresse. In a very remarkable report,[1] he gave an account of the interesting labors of Rémy and Géhin, and, while pointing out that the discovery of artificial fecundation dated back into the last century, he proclaimed that the fishermen of La Bresse were the first to make application of it among us, and that they have the merit of having thus created a new branch of industry in France. The learned Dean of the Faculty of Sciences of Paris resolved upon a grand experiment of stocking the waters of France with fish, and regarded the success of it as probable, if the processes were judiciously arranged. It appeared to him that the best recompense which the government could make to the fishermen of La Bresse, would be to give them the direction of the enterprise. The Philomatic Society did not hesitate to put forth a similar wish by the organ of M. de Quatrefages.

The first notice of M. de Quatrefages, the promulgation of the success obtained at La Bresse, and the favorable report of M. Milne Edwards, gave a powerful impulse to pisciculture, and induced varied applications of it on all sides. Under the influence of these first labors, commenced, in many parts of France, the grand trial which is now going on. Its value will not be fully known till it is completed; but it is already sufficiently advanced to permit us to hope that in the majority of cases the method of artificial fecundation will produce important results. A certain number, both of eminent men of learning, and of men of practical skill, have taken part in this movement, which,

[1] Annals of the Natural Sciences. Third Series, Vol. xiv., p. 53. 1850.
[2] Journal of Practical Agriculture, of June 5, 1852.

far from slackening, increases on the contrary, and is extending daily more and more. Among those who have contributed most by their writings or their practical studies to the continually increasing progress of pisciculture, besides Rémy and Géhin, besides M. Milne Edwards and M. de Quatrefages, we must mention M. Valenciennes, whose knowledge of ichthyology is so extensive and profound, M. Millet, inspector of waters and forests; M. Coste, professor in the College of France; Messrs. Berthol & Detzem, engineers of bridges and causeways; Mr. Paul Gervais,[1] at Montpellier, Mr. J. Fonmet,[2] at Lyons, Mr. F. Defilippi,[3] at Turin.

M. Valenciennes[4] has, at least in part, realized the hope which has often been indulged, of transporting and domesticating in the waters of France the most esteemed fish of foreign countries. He has succeeded in bringing alive from the Spree to the reservoirs of Marly, five different kinds, each represented by a certain number of individuals. There are the *sander*, (*perca lucioperca, of Linne*,) the *wels* or *silure*, (*silurus glanis, of Linne*,) the *alandt*, (*cyprinus jeses, of Block*,) the German *lotte*, (*gradus lotta, of Bloch*,) and the *pitzker* (*cobites fossilis, of Linne.*) This trial has only been made on a small scale, but it is none the less important on that account, since it proves that, in ordinary circumstances, difference of waters would not be an absolute obstacle to the acclimating of foreign fish.

The same gentleman was afterwards charged by the Minister of Marine with the duty of inspecting the fisheries of our coasts. The report, in which were embodied the observations made in the course of this mission, has remained unpublished, and it is to be regretted that the learned ichthyologist was not able to continue and extend these researches, to which his previous studies so naturally called him.

It is worthy of notice what wise circumspection Messrs. de Quatrefages and Milne Edwards have employed in presenting the advantages which rural economy might derive from the method of artificial fecundation. They have incited the proprietors to

[1] Bulletin of the Society of Agriculture de l'Herault, July, 1852.

[2] Memoirs of the Society of Agriculture of Lyons, May, 1853.

[3] Importanza economica dei pesci e del Coro allevamento artificiale.

[4] Report on the Species of Fish in Prussia, which might be imported and acclimated in the fresh waters of France.

attempts which appeared likely to be advantageous, but without always promising them certain results. M. Coste has proceeded with less reserve. With unlimited confidence in the future of pisciculture, he has allowed no occasion to pass without exalting the benefits which it will confer. In his first report, at the close of the year 1850, he declared already "that there is no branch of industry or husbandry, which, with less chance of loss, offers an easier certainty of profit."[1] Later he speaks with enthusiasm of the means, tried during a century, of providing for the repopulating of the waters. Most certainly it is with excellent intentions, and, doubtless, in the hope of sustaining the efforts of experimenters, that M. Coste thus undertakes to guarantee future results; but is it not rather to be feared that, in magnifying too greatly some partial successes, he may compromise the general success of the undertaking. Meanwhile, though these absolute affirmations seem to justify, to some extent, some criticisms of which the learned Professor has been the object, they cannot diminish his share in the improvements recently made in the method of Jacobi.

M. Coste first put in practice the means proposed by the Baron de Riviére for transporting the "*mounting*" or the young eels, and raising them in confined spaces.[1] After having brought this mounting from the mouth of the Orne to the College of France, in flat paniers, overlaid with aquatic plants, he gave them for nourishment a hash composed of the flesh of animals, which do not serve for food of that of molluses and earth insects. The little eels which, on arriving, had an average length of six and seven centimétres, (two and one-half to three inches,) and a circumference of one centimétre, had arrived, after twenty-eight months of this diet, at thirty-three centimétres of length, and seven of circumference. M. Coste remarks with reason, that the corpses of the vertebrated animals, which are not fit for the food of man, might be made useful in this manner. He adds that the noxious insects would serve quite as well to fatten the fish. "Thus a great service would be rendered to agriculture, since it would, in the end, be delivered of one of its scourges." It is to be regretted that the learned Professor has not entered into any details upon the best method of capturing

[1] Practical Instructions upon Pisciculture, p. 34.

these insects, which the cultivators have so great an interest in getting rid of, even if they could not make a profitable use of them.

The author of the Practical Instructions upon Pisciculture has been at length induced to take charge of the organization of a vast establishment of artificial fecundation. In 1850 the two engineers of the canal from the Rhone to the Rhine, Messrs. Detzern and Berthol, after having visited La Bresse on the invitation of the Prefect of the Doubs, had applied at Huningue the me'hod of Rémy and Géhin. Upon the basis of their first experiments they had undertaken hypothetical calculations, from which it appeared that the present population of the waters of France does not exceed twenty-five millions of fish, producing annually less than six millions of francs ($1,200,000) —which figure is really much too large—while, if the process of artificial fecundation were everywhere introduced, the number of fish would be raised, after four years, to three thousand one hundred and seventy-seven millions, and would produce a revenue of nine hundred millions of francs ($180,000,000.[1]) At Lochlebrunn, some kilométres from Huningue, Messrs. Detzern and Berthol had established the foundations of a large preserve, where in 1852 they operated numerous fecundations, by means of a hatching box, which in no respect differs from that of Jacobi. They assert that they have there obtained a cross of the trout and salmon.[2]

The minister of agriculture directed Mr. Coste to visit the new establishment. In a report, favorable to the labors of Messrs. Berthol and Detzern,[3] the professor of the College of France asked for and he succeeded in obtaining a considerable development of the fish preserve or *piscifactory*, as he proposed to call it. He brought into use on a large scale a hatching apparatus which we shall have to describe, adopted all the measures which he thought most fit, and in his memoir upon the means of restocking the waters, of France he undertook, before the Academy of Science, to make a delivery in June, 1853, of

[1] Artificial Fecundation of Fish. Society of Emulation of the Doubs, p. 18. 1851.

[2] Report upon the facts proved at Huningue from May 8, 1851, to May 7, 1852.

[3] Practical Instructions in Pisciculture, p. 96.

six hundred thousand trout and salmon, large enough to be thrown into our rivers. We have not visited the establishment of Huningue, and known not whether it is organized in a way to fulfil a part of the promises which its founders have often put forward; but from the information which has reached us from several quarters, it would seem that their success has not always been as complete as was hoped for at first. It is then much to be feared that after four years, and even more, the establishment of Huningue will not have succeeded in alone restocking with fish all the waters of France, and in making them produce the nine hundred millions of francs promised by Messrs. Berthol and Detzern.

However this may be, the relations established between this *piscifactory* and the College of France, have furnished to M. Coste an opportunity of making some curious observations on the transport of the eggs, and the duration of their vitality after having been taken from the water. Some eggs of salmon and trout, sent from Mulhousen by the diligence, were hatched in great numbers at the College of France. The precaution had simply been taken of surrounding them with moist aquatic herbs in a tin box pierced with holes on the upper side.[1] Other eggs, artificially fecundated, arranged in layers with wet sand in a pine box, remained thus two months in a cold chamber. At the end of this time, they were only corrugated; but having placed the box in water to moisten them through the sand, M. Coste saw them soon resume their natural appearance, and they hatched soon after.

To render possible in his laboratory the experiments which he had undertaken, M. Coste had to adopt an apparatus occupying but little space, and for which a simple thread of water would suffice. The arrangements which he chose, are very simple. This apparatus, which, by the way, we have often seen in operation, is an assemblage of little troughs, arranged like steps on each side of an upper trough which serves to supply all the others. The bottom of each trough is covered with a bed of gravel. A stop-cock lets fall a continuous thread of water into one end of the upper trough. A current is thus created towards the other end, and there an opening at the sides giving

[1] Comptes Rendus of the Academy of Sciences, Vol. xxxiii., p. 124. 1852.

it passage to right and left, it breaks into two falls of water which go to feed the two troughs placed immediately below. These last have also openings by which the water falls into the lower troughs, the number of which may be increased at pleasure.

After the hatching obtained by this apparatus, M. Coste was able to inclose two thousand young salmon into a canal of baked earth, having fifty-five centimétres in length, (twenty-one inches,) fifteen in breadth, and eight in depth, where, says he, the current is kept up by a simple thread of water of the size of a straw. He gave them for nourishment a *paste formed of muscular flesh reduced to fine fibres*, in preference to the boiled blood of which Rémy and Géhin had made use. A salmon raised in this manner in an artificial pond, two metrés in length, (eighty inches,) and fifty centimétres in breadth, (nineteen and one-half inches,) was, at the age of six months, larger than those of the same age taken in the Scottish rivers, and represented in the work published under the assumed name of Ephemera.[1] Such are the principal results to be ascribed to M. Coste. He has recently collected his memoirs and reports into a volume, under the title of *Practical Instructions upon Pisciculture*. He sets forth in these instructions the knowledge previously acquired, and those which he has drawn from his personal experience, and he adopts some of the improvements introduced by M. Millet in the practice of the new industry. We regret that the author of this little work, written with much elegance and clearness, has not oftener cited the sources from which his information is taken.

The same day upon which M. Coste presented his work to the Academy of Sciences, M. de Quatrefages read before this learned body some researches upon the milt of certain fresh water fish.[2] The question here treated of is fundamental, and before it had been resolved, it was impossible to use the necessary precision in artificial fecundations. This labor is then of great importance in the double point of view of comparative physiology and the application of zoology. We know by the experiments of

[1] The Book of the Salmon, by Ephemera, assisted by Arthur Young. See also the Agronomic Annals, Vol. i., p. 234. 1851.

[2] Comptes Rendus of the Academy of Sciences, session of May 30, 1853, Vol. xxxvi., p. 936; Annals of the Natural Sciences, third series, Vol. xix., p. 341. 1853.

Prevost, of Geneva, and of M. Dumas, that the milt owes its physiological properties to the presence of animalcules, which move in a manner very peculiar, and that all fecundating power disappears the moment that these animalcules die. Now, M. de Quatrefages shows that the duration of these movements is extremely short in the case of fish, even in the most favorable circumstances. Thus, in the milt of the brochet, diluted with water, all vitality ceases after eight minutes and ten seconds. The animalcules of the mullet are all dead after three minutes and ten seconds, and those of the carp after only three minutes. This period of activity is still more limited for the perch and barbel, since it only reaches two minutes forty seconds for the former, and two minutes ten seconds for the latter. Neither is it equal for all the animalcules of the same fish, and half of them perish in much less time. Besides, the preceding figures are taken at the degree of heat most favorable to the duration of these movements, and even slight variations above or below this point destroy them with great rapidity. The temperature which maintains longest the vitality of the animalcules is, for winter fish, like the trout, forty-one to forty-eight degrees of Fahrenheit; for those of the early spring, fifty to fifty-five degrees; for those of later spring, as the carp and the perch, sixty-three to sixty-eight; and for the summer kinds, seventy-seven to eighty-seven. When the temperature somewhat exceeds these limits, the increase of energy on the part of the animalcules, compensates, to a certain extent, for the shorter duration of their vitality. These results apply to those which are disseminated through the water; when they remain united in small masses, they die much more slowly. The peculiarities of the milt may thus be preserved for a much longer time, when it is not diluted, and especially when it is kept at a very low temperature. It may even be frozen without causing, in all cases, the death of the animalcules. "M. Millet, who has aided me in all these researches," says M. de Quatrefages, "has thought of putting the milt with ice into a tin box, so that the water may run out as the ice melts, and then to arrange this box in a second wooden one, pierced with very small holes, and itself filled with ice." Thanks to these precautions, the learned academician has been able to preserve the milt in a serviceable condition during sixty-four hours. It is worthy of remark that the fecundating pro-

perty disappears first in that part of the male organ where the liquid is most completely elaborated, and endures some time longer in the deeper parts.

These facts, taken together, will explain most of the failures resulting from operations apparently well conducted. They show that the manipulations must be accomplished with great quickness, and careful attention must be paid to the temperature of the water. We may conclude from them also that the season of spawning in certain localities must vary in accordance with the atmospheric phenomena—that the short vitality of the milt is one of the causes which oppose the crossing of the different species in nature, and that the hitherto unexplained instinct which leads the trout and salmon to mount to the sources of water-courses, is owing to the need felt by these animals of finding a degree of temperature suitable to the fecundation and development of their eggs. M. de Quatrefages has also deduced from his researches data of great value for practice, and eminently suited to regulating the methods of artificial fecundation.[1] The results contained in the memoir of M. de Quatrefages give to these methods a scientific regularity, which they have wanted hitherto, and tend to endow pisciculture with fixed and precise rules.

To complete the summary picture of the progress which pisciculture has made from antiquity to our time, and to show its present condition, it remains to point out the numerous and important improvements which are owing to M. Millet, inspector of waters and forests.[2]

It is a well known fact that fish do not deposit all their spawn

[1] Since the male liquid, completely elaborated, loses first its fecundating properties, only that should be used in doubtful cases which is pressed from the milt itself. The vitality of the animalcules not being destroyed by cold in the male organ, the frozen milt is not to be rejected as useless. If the fecundation cannot be made till after the death of the animal, it is well to take out the milt and preserve it in a wet cloth. In view of the extreme shortness of life of the animalcules, and of the obstacles which the swelling of the envelope may oppose to fecundation, it is useful in the case of certain species to pour the eggs and the male product simultaneously into the same vessel, and thus to render the contact instantaneous. Of course the water must never be first impregnated with the milt.

[2] Report to the Director-General of Waters and Forests, upon the repopulating of the navigable and floating water-courses, by M. de Saint Ouen,

at once. The eggs do not all arrive together at a state of maturity. When left to herself the female returns several times to the place of spawning, where the male always follows her, and it is only after a certain number of days that the delivery of the eggs is complete. Although it has been already remarked that only the ripe eggs leave the ovary and find their way into the abdominal cavity, yet the advice was always given to effect the artificial fecundation at once, by forcing out the spawn by pressure on the sides of the belly of the female. Without doubt, this practice in many cases was attended with a violence as injurious to the development of a great number of the products as to the health of the animal thus operated upon.

Struck with these inconveniences, and convinced of the advantages always following from a strict imitation of nature, M. Millet took pains to gather the eggs only in portions and in several days, as they became completely ripe, and to let them fall into the water simultaneously with the milt of the male. As captivity has often a bad effect upon the generative functions of fishes, M. Millet only takes them at the moment of making the fecundations, and restores them to the river immediately after, at the same time tethering them with a packthread passed through the gills. They live very well in this condition, and do not perceptibly suffer from it. M. Millet has also sometimes made use of artificial spawning holes which call to mind those of Lund, but are more perfect. These are a kind of double bottomed cages, the first consisting of an open framework of bars, the second of a movable sieve of metallic

Administrator of the Forests. March, 1853. Annals of the Forests, pp. 272 and 429. July and August, 1853. Independently of the various memoirs upon pisciculture, which we have hitherto cited, it may be useful to consult the report of a commission of the king of Holland, having for title, Handliedung tol de Kumtmatige Veremenigouldigen var Vischen, 1853; some notes of M. de Camnont in the Norman Annual for 1850, and in the same collection an Essay upon the Multiplication of Fish in the department of La Manchi, by M. G. Sward de Becunlieu, 1854, as well as some letters of the marquis of Wibraye and the count of Pontgibard, 1854; in the Analytic Sketch of the Labors of the Academy of Rouen, a note by M. Bergasse on Artificial Fecundation applied to the Salmon, 1853; and some Researches into the Natural History of the Salmon, by M. A. de Bignon, 1853; finally, various observations of M. M. Géhin, Richard de Behagne in the Bulletin of the Agricultural Society of Paris, Vol. vi., p. 461, and 469, 1851; of M. Noblet, *ibidem* Vol vii., p. 403, 1852, and of M. Quenard, *ibidem* Vol. viii., p. 95, 1853.

cloth. The females, by rubbing against the bars, let fall their eggs which drop upon the sieve. The males being introduced into the apparatus at the same time, it generally happens that the fecundation is effected naturally. This method of gathering has the advantage of losing no portion of the eggs, while there is risk of this in holding the female by a cord in rivers.

The hatching apparatus used by M. Millet varies a little with circumstances, but remains always simple, convenient and economical. If the development of the egg is to take place out of the water in which the parents live, whether in an apartment, or under a shed, a vessel of any description is taken, having a capacity of thirty to thirty-five litres, (eight to nine gallons,) and on the bottom of this, gravel, sand and charcoal are heaped up so as to constitute a filter. A purified water runs from this reservoir by a stop-cock situated underneath it, and falls into troughs placed like steps, which may be multiplied at pleasure. This arrangement is entirely similar, as we see, to that which M. Coste had already chosen, but M. Millet has added an improvement, which, we hasten to say, the learned professor of the College of France has at once adopted in his turn.

However pure running water may be, it always bears with it and deposits at the bottom, which it covers, foreign particles, which, if they rested upon the eggs, would finally surround them with a sort of slime favorable to the development of byssus and mould. To meet this objection, M. Millet thought of suspending the eggs a little below the surface of the water. M. Vogt[1] had already taken the precaution to place them in a muslin bag, permeable on all sides, which he threw into the lake after having fastened it to a stake, or kept it in place by a large stone. Starting upon the same principle, M. Millet has arrived at a surer and more complete result. He places the eggs upon sieves, which little rods, sliding on the edges of the tubs, hold at the desired height. This skilful experimenter has successively employed sieves of various substances, of hair, of silk, of willow, &c., and has finally given the preference to galvanized metallic cloth, which have more solidity and durability, do not spoil, are

[1] Embryology of the Salmon, Natural History of Fresh Water Fish, by L. Agassiz, p. 16. 1842.

easily cleaned by the help of a brush, and are only very rarely attacked by sea-weed.

The expense of outfit of such an apparatus is quite insignificant. The working consists merely in filling the reservoir every morning and evening, in moving the sieves once a day, and taking away the eggs which may become opaque. For many years the eggs of trout, of salmon, of the umber, &c., have been developed in this way, and hatched in considerable quantities in the same apartment which the experimenter occupies at Paris, in the middle of the rue Castiglione.

When the process can be carried on in the water of a stream itself, of a lake or of a pond, M. Millet recommends the employment of double sieves of metallic cloth, which may be kept at a suitable height by the help of floaters, and which follow all the changes of the level of the water. For the species which spawn in sleeping water, he lines the double sieve with aquatic plants, or limits himself to placing the eggs in large shallow tubs with plants which prevent the water from corruption. When the fecundated eggs are to be transported to great distances, M. Millet advises placing them in a flat box, in quite thin layers, between two wet cloths. In this state he has sent them to Florence, where they have reached the hands of M. Vaj and the Professor Cozzi, after a journey of twenty or twenty-five days, and have not failed to hatch soon after. The use of moist linen is preferable to that of aquatic plants; the linen dries less rapidly, and facilitates the unpacking, which, in the other cases, requires much time and care. The Marquis of Vibraye, to whom the Sologue owes so many useful improvements, and who has already introduced on his estates numerous trout produced by artificial fecundation, has also made use, with advantage, of small wadded cushions. When the eggs to be dealt with are very delicate, and are to be transported during the summer, M. Millet sometimes employs the little portable ice box, of which we have already given the description.

As soon as the young fish have completely absorbed their umbilical vesicule, that is to say, some weeks after the hatching, the author of these curious experiments is of opinion that it is best not to try to nourish them in captivity, but to dismiss them at once into the waters where they will have to live, taking care, however, to place them suitably where they will find the spawn

of frogs, lymnites, planorbes, &c. They should commence at once to seek for their prey, and thus avoid the suffering from change of water, of nourishment, and of habits, to which they will necessarily be subject, if raised artificially in basins not communicating with the waters which they must inhabit.

It is principally in the departments of the Eure, the Aisne and the Oise, that M. Millet, has put in practice these various methods. Affidavits emanating from the local authorities, bear witness to the important results which he has obtained. M. Millet has conducted, at the same time, a series of delicate observations, which have already led to some happy applications.[1] He has examined the action of salt or brackish water on the eggs of fish, which leave the sea to spawn in fresh water, and he has seen that it is injurious to their development in ordinary cases, which gives the practical reason of the emigration of these animals. Nevertheless, salt, which would destroy the healthy eggs, has the singular property of healing them, when attacked by white spots. These spots, which probably spread from the service to the centre, and would lead to the destruction of the eggs, if allowed to increase, disappear in water very slightly salted, and when they are taken in time, the young fish may thus be saved. It results also, from the observations of M. Millet, that the mortality of the eggs always reaches its maximum at the epoch when the embryo begins to form; accordingly, he advises transporting them only when the eyes become visible, or rather immediately after the fecundation. He has remarked finally, that the white spots on the one hand, and the sea-weed and byssus on the other, attack much more rarely the eggs of trout and salmon, at a low temperature, than in one which exceeds fifty-four degrees.

Here terminates the rapid exposition of the applications furnished by zoology to the economy of ponds and water-courses, and of the progress which this branch of industry has made of late years. The labors of Rémy and Géhin, and those of M. de Quatrefages, of M. Coste and M. Millet, represent the present state of this department of agricultural science. To them be-

[1] Comptes Rendus of the Academy of Sciences, Vol. xxxviii., session of December 26, 1853.

longs the honor of having regulated and perfected the methods, and of having determined the basis of a cultivation, before very vague and precarious.

III.

The processes which we have analyzed are not all equally adapted for easy and profitable application. It remains then to compare the respective advantages of them, to determine the combined measures which pisciculturists ought to adopt.

The first care to be taken, when it is desired to stock a river or pond, is to learn what species of fish will best adapt themselves to the circumstances which happen to be united there. To escape the danger of certain failure, it is first of all necessary that the nature, the ordinary temperature, the depth, and the various qualities of the waters to be enriched, should agree with the instincts, habits and way of life of the animals to be developed there. These recommendations are found in all books upon the subject, but cannot be too often repeated. It is most certainly from the neglect of these proprieties, and want of appreciation of them, that certain pisciculturists have seen their attempts miscarry, when they were otherwise skilfully executed.

When, therefore, the ground, as it were, has been studied in advance, and it has been determined what sort of fish has the best chance of prospering there, the individuals necessary for the multiplication of the chosen species should not be procured except at the very season of spawning, since very often the products are spoiled in the bodies of fishes which are condemned to close captivity. This inconvenience does not present itself if the animals can be placed in reserve in inclosures near the rivers or ponds in which they have been caught. Otherwise they may be held by a cord in the same places where they have lived. It is important, before effecting the fecundation, to pay attention to the temperature of the water, which has so great an influence upon the properties of the milt, as M. de Quatrefages has so clearly shown, and probably also upon the vitality of the egg itself. Although M. Vogt has seen the eggs of the palee[1]

[1] A kind allied to the salmon.

prosper after they had been taken in ice, this extreme cold is generally sufficient to destroy them.

The gathering of the male and female elements should be made on different occasions and in several days. It seems useful, in many cases, to guard the products from all exterior influences, and not to take them from their natural medium. For this purpose a male and female are taken and inclined near each other, at the surface of the water. They are then bent gently upward, which produces a strong contraction, and generally serves to create a flow of the ripe products. If the exit offers any difficulty, it may be assisted by passing the finger under the belly, but without any effort. The simultaneous, or almost simultaneous mixture of the eggs and the milt, is necessary in most cases, since with certain fish, as the trout, the animalcules of the milt do not live even a moment, and with others, as the carp, the mucilaginous envelope of the egg swells rapidly in the water, and then opposes itself to the impregnation. For the last reason, it is important always to refrain from washing the eggs before fecundation, as some persons had advised doing.

The eggs once fecundated are placed in an apparatus like those of M. Coste and M. Millet, but it appears to us preferable in all cases, when possible, to employ the double sieve or floating inculator of the last experimenter. The fecundation is then effected in the lower part of the sieve, placed in a tub full of water, and after the cover is put on, the whole is transported to the river which is to be furnished; in this way, the spawn undergoes no change of water, from its exit from the belly of the female to the period of its development. If the eggs are unencumbered, they are allowed to fall to the bottom of the sieve. If they are adherent, like those of the carp, the tench, or the barbel, care is taken to introduce beforehand into the sieve some aquatic plants or twigs. The little apparatus is furnished with floaters, and fastened to stakes by a cord, by which it is easy to draw it to the bank, when it is to be examined. After the young fish are hatched, and their umbilical vescicule is completely absorbed, the sieve is opened, and they are thus dispersed in the very places where they are to live. With this view, shallow places are chosen, which the fry generally prefer, and which are not frequented by the large fish, or rather inclosures near the water-courses. The fish of this early age

have great agility, and commonly escape the pursuit of their enemies by squatting among the pebbles, and concealing themselves in the grass or the roots of trees. They then feed naturally upon lymnites, planorbes, small worms, or the spawn of frogs, but it soon becomes useful to throw them the refuse of the shambles or the kitchen, and, generally, as M. Coste has advised, all animal substances which are not made use of. It would seem, however, that some of these substances may become injurious to the fish, and M. Sivard de Beaulien has remarked that his trout always died after eating earth salamanders. The putrefaction of the substances which are not eaten, offers no inconvenience in a mass of water frequently renewed like that of a brook, while for this reason, and many others, the artificial nourishment of young fish in narrow reservoirs is almost impracticable. They should, therefore, always be dispersed after the absorption of their vesicules, without attempts to raise them painfully in small apparatus.

These various operations are, as we see, very simple and easy, and may be brought to a good result by any body with little outlay of time and expense; but it is evident that success depends greatly upon the tact and foresight of the operator, and that here, as in all branches of industry, individual skill will always have great influence upon the result. Without doubt, also, a prolonged and sufficiently extensive experience will soon attain to further improvements in the application of the new methods, and reduce greatly the chances of failure. Every thing, then, gives reason to hope that at an early period pisciculture will be naturalized among the useful sciences, and that it is destined to solve one of the important terms of the great problem of cheap living.

This result, so desirable, would be greatly expedited if the government should decide to take some energetic measures. It should cause to be completely revised, by competent men, the legislation of the fluvial and marine fisheries, and should bring the system of artificial fecundation into operation in all the fresh waters of France, at the same time that a service of observation and vigilance should be organized upon our coasts. In uttering this wish, we are only the echo of all the learned men and economists who have touched upon this question.

Already, indeed, the state has made a first step in the path

where we should like to see it wholly enter. It has decreed the piscifactory of Huningue. We are far from denying the services which this establishment may render by its consequences; but it is clearly proved that it will never suffice for entirely restocking the waters of France, and meets very imperfectly the present wants of pisciculture. If there are too great obstacles to putting this vast trial in practice over the whole surface of the country, it would at least be easy for the state to undertake it in more limited, though still considerable proportions, and without charging the budget with any new burden. For this purpose it need only profit by the resources offered by the administration of waters and forests. In fact, this administration disposes of a surface of canals and brooks which reaches nearly 8,000 kilométres, (5,000 miles,) and has a personal force quite ready and trained to the various practices for the husbandry of the waters. The number of its simple fisheries police amount to 427, without counting the general police, sub-inspectors, and inspectors which direct the others, and who are all prepared by their previous studies for applications of this kind. Here is a service extensively organized, which would be admirably adapted to experiments of pisciculture on a large scale, and which would not even thereby be turned from its legitimate functions.

It is to be hoped that those who are interested will not fail to be struck with these easy advantages, and that they will try to attain to at least a part of the results promised by the new industry. Relying upon their own resources, the proprietors have not hesitated to undergo the risks of the trial; but apart from their isolated and limited efforts, does it not belong to the state to give prosperity and extension to the methods devised by Jacobi, and already carried by men of science in France, to so high a degree of perfection.

JULES HAIME.

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